

CHEMISTRY



MERIT BADGE SERIES

BOY SCOUTS OF AMERICA

STEPS IN EARNING A MERIT BADGE

When you have decided on a subject that interests you, first read the merit badge pamphlet and become familiar with the requirements.

Your Scoutmaster or Explorer Advisor will give you an application to fill out and tell you how to get in touch with the merit badge counselor who will help you.

Telephone or call on the merit badge counselor. Ask him when you may have a talk with him. Be sure to keep your appointment **AND BE ON TIME**. Perhaps you will have several meetings with the counselor. To help you in your preparation, he may suggest things for you to do, other people to see, or an interesting book to read. He may teach you some simple skills that will start you off on the right foot.

Now you are ready to go to work in earnest. Lay out a plan of what you will do to finish each required project. Refer to your merit badge pamphlet frequently. Get help from other Scouts who have earned the merit badge, Dad, other members of your family, your teachers, or your neighbors.

When you are sure that you have learned and done all the things that the requirements call for, go back to your counselor. He will test your knowledge and skill and examine your exhibits if any are required. He may suggest that you spend a little more time on one or two of the requirements. At last, though, if you stick with it, you will meet all of the requirements satisfactorily. The counselor will then approve your application.

Turn your application in to your Scoutmaster or Advisor. He will forward it to the local council, and you will receive the merit badge later at a court of honor.

CHEMISTRY

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REQUIREMENTS

1. Do one of the following:
 - a. Collect 10 compounds or elements found in the home and write the common name, chemical name, and formula or symbol for each.
 - b. In company with your Counselor, follow a route selected by him and name 15 compounds or elements found in nature or in objects seen along the way.
2. Perform experiments to illustrate *four* of the following chemical reactions:
 - a. Neutralization, using an indicator.
 - b. Precipitation of a solid from solution.
 - c. Evolution of a gas.
 - d. Combination of two elements to form a compound.
 - e. Replacement of a metal in a salt by another metal.
3.
 - a. Demonstrate and discuss the chemistry of a candle flame. Relate this knowledge to the burning of wood as in a campfire.
 - b. Explain how (1) water and (2) sand act to extinguish campfires. Tell what methods are recommended for extinguishing fires involving: (1) cooking fat, (2) oil or gasoline, (3) electrical equipment. Explain how each functions.
4. Explain the changes that occurs in nature's (a) water cycle, (b) carbon-oxygen cycle, (c) nitrogen cycle. Describe the chemical reaction that takes place in carbon monoxide poisoning.
5.
 - a. Explain what is meant by "hard water" and "soft water."
 - b. Do *one* of the following:
 - (1) Perform experiments to show how the hardness of water may be reduced.
 - (2) Demonstrate the action of soap and synthetic detergents in hard water and explain any differences observed.

6. Tell how the chemical properties of iron, aluminum, copper, and silver influence their usefulness as cooking utensils, as tools, or for other purposes around the camp and home. Describe several means of preventing metal corrosion.
7. Do one of the following:
 - a. Visit an industrial plant that makes chemical products and describe the processes involved.
 - b. Visit a laboratory or a commercial establishment using chemical materials and find out how and why the materials are used.
 - c. Visit an experimental farm to learn how chemistry is meeting local problems of soil fertility and pest control.
 - d. Collect samples representing, (1) the manufacture of chemicals from a common source, such as salt, sulfur, or petroleum; OR, (2) the use of chemicals in the manufacture of a class of products such as textiles, drugs, or metals. Be prepared to discuss with your Counselor the chemistry of the subject chosen.
8. Do one of the following and be prepared to discuss with your Counselor the chemistry involved in it.
 - a. Make soap from materials available around the campsite or the home.
 - b. Make an electric cell and use it to demonstrate electroplating or the electrolysis of water.
 - c. Treat a piece of cloth or canvas to make it water-repellent.
 - d. Make a two-color flag or pennant by dyeing and/or bleaching cloth.
 - e. Perform experiments and chart experimental data to illustrate *three* different temperature effects of salts in solution.
9. Explain how principles expressed in the Scout Oath and the Scout Law are observed by scientists.



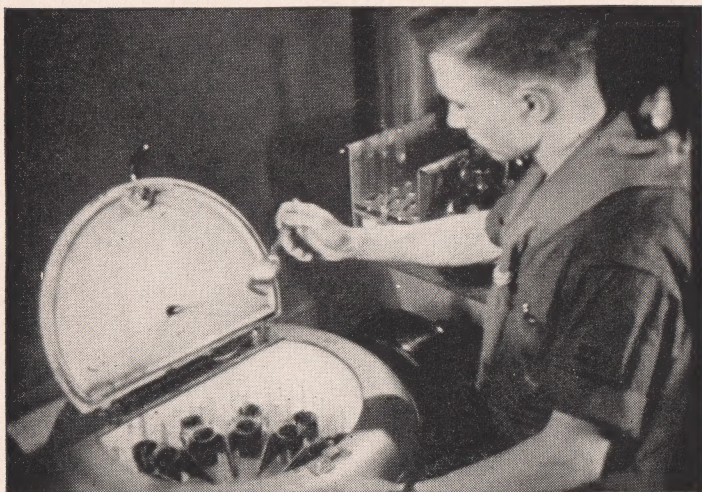
CHEMISTRY

By CLIFFORD D. CARPENTER,
Professor Emeritus of Chemistry in
Columbia University.

HOW SHOULD A SCOUT PREPARE FOR THE MERIT BADGE TEST IN CHEMISTRY?

Chemistry is an experimental science and progress will be difficult unless the Scout can have the guidance of one experienced in the subject. A good High School course is the best foundation. After completing such a course, any Scout should be able to meet the requirements for the Merit Badge in Chemistry.

Those who intend to attempt to prepare themselves without the advantages of such a course should secure the interest and guidance of some one prepared in the subject who can give the time which will be required. It is also possible for some to get a satisfactory training from a correspondence course.



No doubt many of the books and periodicals listed in the back of this pamphlet are available to you at your local public library. The use of a modern High School textbook of Chemistry is, of course, desirable.

If no such text is used in the High School in your community, the one most used in the State might be selected. You can write to the State Commissioner of Education at the State Capital, for the information. Advice might be sought from the Chemistry Department of a college or University near you. Let us now turn to the subject matter of chemistry.

CHEMICAL VIEWPOINT OF MATTER

WHAT IS CHEMISTRY?

Whenever we wish to understand the nature of our universe and what is going on in it, we make careful observations, measurements, and calculations until we arrive at a satisfactory explanation. Such a method is called the scientific method. Just what observations, measurements and calculations we make depends upon what we wish to know. If we wish to know something about the relations of the planets, distances apart, relative movements, etc., we appeal to astronomy, if about plants, to botany, if about animals to

zoology, if about the earth, to geology, and if we wish to understand the nature, i. e., the make up of any piece of material we appeal to chemistry.

Astronomy, botany, zoology, geology, and chemistry are only five of many subdivisions of science. Not only are there major subdivisions of science but each science has been subdivided many times. Chemistry e. g. as a pure science, has four major subdivisions, inorganic, analytical, physical, and organic, and as an applied science biological, food, physiological, agricultural, iron and steel, electrical, paper, leather, textile, rubber and many more.

It becomes at once apparent that chemistry is a very large branch of science, and enters into every moment of our life. What it really is will only become revealed as we study it. Let us now turn to other questions.

HOW OLD IS CHEMISTRY?

At the time of the American Revolution all the materials of our world were classified under four headings, earth, air, fire, and water. The earth was known to be made up of many different substances, but the real nature of air, fire, and water was not known. Fire was held to be a substance, and was called *phlogiston*. It was not known that the air is a mixture of gases. Indeed it was more than one hundred years later before the rare gases of which helium is one, were discovered. It is extremely interesting to note that the last half of the eighteenth century 1750-1800 was the turning point in uncovering the mystery surrounding the nature of the substances making up our universe. The Phlogiston theory of fire was overthrown and a real start made to resolve all substances into stable, simple substances. We have assumed for more than one hundred years that all substances are either simple i. e., contain only one kind of substance or are compound, i. e., are made up by combinations of the simpler substances. We have assumed that the simple substances are relatively few, while the compound substances occurring in nature or artificially produced by bringing together various substances under the proper conditions are countless. All evidence has borne out these assumptions, and the branch of science employed in establishing the soundness of such assumptions, is our modern chemistry. The effort to discover the "philosopher's stone," i. e., some magic

substance which would convert baser substances into more precious, prolong youth, cure sickness, and prevent death as well as the development of certain applied arts is the background upon which our modern chemistry took root. The physician of today uses much of the knowledge gained by these early workers. Applied chemistry uses many of the same methods used by those working in the industrial arts of the early period.

These early efforts to understand and use substances extended over many centuries. Chemistry as a science was very crude, yet we must not discount what was known. The extraction of a few metals from their combinations had been accomplished, glass and other useful substances had been produced, but the chemical changes were not understood. During the last one hundred and fifty years, the chemist has organized the earlier knowledge, and by experimentation discovered new facts and developed a method of approach in the study of chemical phenomena. In other words the chemist has a viewpoint which guides him in his study. As we study what the chemist has learned and how he works we will gradually develop his viewpoint.

WHAT DOES THE CHEMIST KNOW ABOUT EARTH, AIR, FIRE AND WATER?

He knows that the earth is made up of a large number of substances—existing in three *states*, solid, liquid, and gas—that the air is a mixture of gaseous substances, that water is a single substance, and that fire is not a substance. Not only chemistry but all science thinks of our surroundings in terms of matter and energy. The substances which makes up earth, air, and water belong to the former and fire belongs to the latter. Fire is an evidence of heat-energy. It is used in a rather restricted sense as it refers to a special case of giving out of heat-energy, i. e., where substances combine with oxygen. As implied in the former statement, there are many other changes in matter which yields energy.

This is certainly a very brief statement of what the chemist knows, but it gives us a general idea which will aid us as we study in more detail what the chemist knows and how he came to know it.

INTERNATIONAL ATOMIC WEIGHTS, 1951

Element	Sym- bols	Atomic Weights	Element	Sym- bols	Atomic Weights
Actinium	Ac	*227.00	Neodymium	Nd	144.27
Aluminum	Al	26.97	Neon	Ne	20.18
Americium	Am	*241.00	Neptunium	Np	*237.00
Antimony	Sb	121.76	Nickel	Ni	58.69
Argon	A	39.94	Niobium (Form Columbium)	Cb	92.91
Arsenic	As	74.91	Nitrogen	N	14.01
Astatine	At	*211.00	Osmium	Os	190.20
Barium	Ba	137.36	Oxygen	O	16.00
Berkelium	Bk	243.00	Palladium	Pd	106.70
Beryllium	Be	9.02	Phosphorus	P	30.98
Bismuth	Bi	209.00	Platinum	Pt	195.23
Boron	B	10.82	Plutonium	Pu	*239.00
Bromine	Br	79.92	Polonium	Po	210.00
Cadmium	Cd	112.41	Potassium	K	39.10
Calcium	Ca	40.08	Praseodymium	Pr	140.92
Californium	Cf	244.00	Promethium	Pm	147.00
Carbon	C	12.01	Protactinium	Pa	231.00
Cerium	Ce	140.13	Radium	Ra	226.05
Cesium	Cs	132.91	Radon	Rn	222.00
Chlorine	Cl	35.46	Rhenium	Re	186.31
Chromium	Cr	52.01	Rhodium	Rh	102.91
Cobalt	Co	58.94	Rubidium	Rb	85.48
Copper	Cu	63.54	Ruthenium	Ru	101.70
Curium	Cm	*242.00	Samarium	Sm	150.43
Dysprosium	Dy	162.46	Scandium	Sc	45.10
Erbium	Er	167.20	Selenium	Se	78.96
Europium	Eu	152.00	Silicon	Si	28.06
Fluorine	F	19.00	Silver	Ag	107.88
Francium	Fr	*223.00	Sodium	Na	23.00
Gadolinium	Gd	156.9	Strontium	Sr	87.63
Gallium	Ga	69.72	Sulfur	S	32.07
Germanium	Ge	72.60	Tantalum	Ta	180.88
Gold	Au	197.20	Technetium	Tc	*99.00
Hafnium	Hf	178.60	Tellurium	Te	127.61
Helium	He	4.00	Terbium	Tb	159.20
Holmium	Ho	164.94	Thallium	Tl	204.39
Hydrogen	H	1.01	Thorium	Th	232.12
Indium	In	114.76	Thulium	Tm	169.40
Iodine	I	126.92	Tin	Sn	118.70
Iridium	Ir	193.10	Titanium	Ti	47.90
Iron	Fe	55.85	Uranium	U	238.07
Krypton	Kr	83.70	Vanadium	V	50.95
Lanthanum	La	138.92	Wolfram (Form Tungsten)	W	183.92
Lead	Pb	207.21	Xenon	Xe	131.30
Lithium	Li	6.94	Ytterbium	Yb	173.04
Lutetium	Lu	174.99	Yttrium	Y	88.92
Magnesium	Mg	24.32	Zinc	Zn	65.38
Manganese	Mn	54.93	Zirconium	Zr	91.22
Mercury	Hg	200.61			
Molybdenum	Mo	95.95			

*Based on theory.

WHAT IS A SUBSTANCE, AN ELEMENT, A COMPOUND?

Whenever you examine a piece of material and discover that it is the same throughout, you call it a substance. We have already mentioned the fact that there are two kinds of substances, simple—iron, copper, gold, oxygen, hydrogen, etc.,—and compound—salt, water, sugar, rust, etc. As a matter of fact the chemist has discovered 98 simple substances, many of which occur in nature. They are termed *elements*, and the compound substances *compounds*. We shall therefore use these terms. A list of 98 elements is given on the preceding page.

Look at the names of the elements given in the first column of the table. Have you heard of many of these?

WHAT IS A MIXTURE AND WHAT IS A COMPONENT?

Take some small pieces of iron (coarse filings) and mix them with small particles of sulphur (the size of rice). Your naked eye can see that each particle of iron remains iron and each particle of sulphur is still sulphur. You can separate them with patience and a pair of fine tweezers, or better still you can remove the iron with a magnet. Thus when two or more substances retain their individual characteristics even though closely associated with one another we call them *components* and the association a *mixture*. A second very striking characteristic of a mixture is that the ratios of the amounts of the components may vary, e. g., you can make a mixture of iron and sulphur one percent iron and 99 percent sulphur, or one percent sulphur and 99 percent iron. There is practically no limit to the number of different mixtures which can be made from iron and sulphur. A third characteristic of a mixture is that the mixing may be fairly well done or it may be poorly done, i. e., any portion may or may not have very nearly the same ratio of its components as any other sample of this mixture. A typical

mixture in nature is granite. It is not difficult to recognize the three substances which are its components—the shiny quartz, the black mica and the flesh-colored feldspar. If you have seen many samples of granite you will recall some more largely shiny and white, some largely dark, and some largely flesh colored, depending on which component predominated. In fact granite illustrates the three characteristics of a mixture.

WHAT IS A COMPOUND, A CONSTITUENT AND A CHEMICAL REACTION?

Mix iron filings and powdered sulphur, about one part (teaspoonful) of iron and two of sulphur. Mix intimately and place in a hollowed place in brick or stone and heat. Very soon the whole mass will begin to glow, and give out heat. When the glow dies out and the mass is cooled, if you look for your iron or sulphur it will be gone, but a new substance will be in its place, entirely different from either the iron or sulphur. The iron and sulphur have united to form a new substance, iron sulphide. A trained chemist could recover the iron and the sulphur, but even for him this is a very difficult task. The union took place by some special process, and in order to separate them it will take more than a mechanical method. The product of such a union is called a chemical combination or a *compound*, and the process by which such a change took place is termed *chemical reaction*.

It is quite evident that the elements in chemical combination have a special kind of hold upon one another. They are no longer simply components, and cannot be called components, so they are called *constituents*. A second characteristic of a compound is that its constituents are always there in a perfectly definite ratio with one another. This is known as the "Law of Definite Composition," and was first formulated by Dalton. You cannot make 2001 pounds of iron sulphide from one ton of iron and one pound of sulphur. You can, however, make 87.9 pounds of iron sulphide by the union of 55.84 pounds of iron and 32.06 pounds of sulphur, when all the iron is used in making iron sulphide.

2000 pounds of iron will combine with $2000 \times \frac{32.06}{55.84}$ pounds of sulphur.

Do you realize that 12 pounds of charcoal (mainly carbon) when burning unites with approximately 32 pounds of oxygen and throws into the atmosphere about 44 pounds of carbon dioxide gas? Think what this means in terms of the thousands of tons of coal burned daily when you realize coal is largely carbon.

A compound, therefore, is always made up of two or more elements in combination, each of which has lost its independence and its original characteristics. These elements are always united in the same ratios in any one compound regardless of the size of the portion of the compound under observation.

Physical Properties

Whenever we attempt to describe a piece of matter we first note its state and then its most characteristic *properties*. Regardless of its state a substance may have color, odor, taste or feel, but most other properties are usually dependent upon the state. In the case of a solid we note whether it is hard or soft, heavy or light, transparent, translucent or opaque, metallic or non-metallic in appearance, brittle or elastic, conchoidal fracture (like glass) or crystalline fracture (like rock salt), malleable (pounded into sheets) ductile (pulled into a wire), conductor of heat or electricity, volatile (easily changed to the gas state like camphor gum) or non-volatile, streak (makes a mark when rubbed against another substance—the mineralogist makes this test of a rock) and whether it is soluble or insoluble in water. In the case of a liquid some of the main properties are, how volatile, whether it is mobile, viscous or oily as well as some of the properties by which we describe solids. In the case of a gas we first note little more than the color, odor or taste and sometimes whether it is soluble or insoluble.

Physical Constants

With the aid of measuring units and implements we can make our observations of the physical properties of a substance, much more valuable if we express them in terms of their *physical constants*, e. g., water is volatile and boils in terms of the thermometer at 100°C. Ice melts, in terms of the thermometer at 0°C. Iron is heavy; so is mercury, but in terms of $\frac{\text{mass in grams}}{\text{volume in c.c.}} = \text{density}$, mercury is 13.56,

and iron is 7.85, i.e., mercury is almost twice as heavy as iron. You may observe that you have a colorless mobile liquid and not know whether it is alcohol, water, or some other colorless liquid, but if you measure its boiling point, you will know at once. In fact, no two liquids have the same boiling point, and a liquid does not register the true boiling point if it contains dissolved impurities. Practically any pure substance can be identified by one of its physical constants:—freezing point; boiling point; or density.

Measurements

We have already referred to the necessity of making accurate observations, and since this can be done only by reference to units of measurement it will be well for us to make a brief review of the systems used in science.

Let us first divide measurements into four major divisions: 1. Space; 2. Temperature; 3. Mass; and 4. Time. For each system, some unit is taken as a standard, e. g., for space the meter, for temperature the degree, for mass the gram, and for time the second. Let us discuss briefly each system.

Space: In order to measure space we consider it in three classifications, linear or distance, square or area, and cubical or volume. If we use the metric system it is sufficient to define only one unit, i. e., the one for linear measurement, for we use it to designate area and volume as well. While the meter is selected as the standard, the scientist uses the centimeter which is $1/100$ of a meter. The units drawn to scale in Fig. 1 are—one centimeter, one square centimeter and one cubic centimeter. The chemist seldom uses

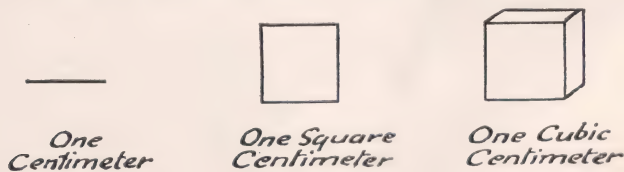


Fig. 1

the first two but constantly uses the last or its multiple. One of the most common multiples is the liter or one thousand

cubic centimeters, usually abbreviated to read 1 L or 1000 c.c. Compare these units with the corresponding English system, yard, quart, etc., and observe how much more convenient they are.

Temperature: A well known property of substances is their expansion or contraction when heat is added or taken away—heated or cooled. This property has been applied in constructing instruments—thermometers—for the measurement of temperature expressed as *degrees*. The term degree is derived from the method of measurement of temperature recorded on an arc of a circle as done in one of the earliest instruments. See Fig. 2.

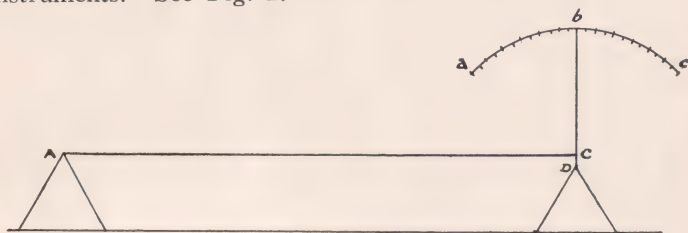


FIG. 2

In the above illustration a metal bar A C is fastened at A and hits a needle at C just above the pivot point D. If the temperature of A C changes, the needle moves so that its free end transcribes an arch a, b, c. If this arc could be made to extend over the extreme change by appropriate lengths of A C, of D to C, and of the needle and change of temperature it would pass over approximately one half of a great circle, or 180° . When Fahrenheit first constructed the mercury glass thermometer he adopted the notation and designated the fundamental temperature interval as the change of temperature of water from its freezing point to its boiling point. Thus the F. T. I. of Fahrenheit is 180° F. He later discovered that salt lowers the freezing point of water an equivalent of 32 of the 180° of the F. T. I. The notation was then changed so that 0° represented the coldest temperature of salt and ice mixture, 32° the freezing point of water and 212° the boiling point of water.

The scientist finds it more convenient to discard the handicap of the historical development so he uses the Centigrade

thermometer whose F. T. I. is 100° representing the change in temperature between the freezing point and boiling point of water. A comparison of the two thermometers is given in Figure 3.

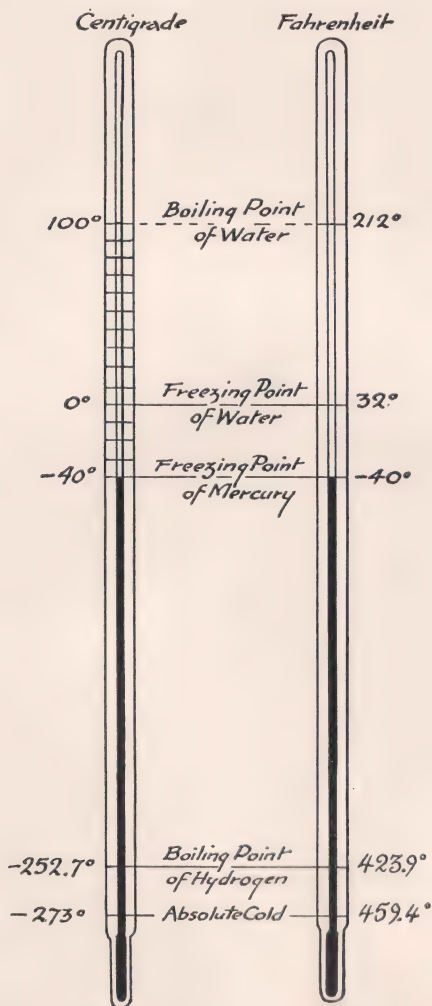


FIG. 3

Mass: The unit of mass used in science is the *gram* and can be best understood by first considering the behavior of water with change of temperature. Let's refer to Figure 4 below. A is a flask with a narrow stem filled to point B in the stem with water at 0°C . Suppose we represent increase of temperature from 0° to 100° , left to right, and imagine that we move the flask $1/100$ of the distance, left to right, each time we raise its temperature one degree, and mark at each point the height of the water in the stem. If we connect these points we get a line which goes down for a short distance, D to E, and then begins to rise, and continues to rise E to F until the water is at 100°C . It will be discovered that the change in the direction of the line took place at 4°C and a moment's thought will tell us that water is at its greatest density at 4°C . It is for this reason that the unit of mass is defined as equivalent to one c. c. of water at its greatest density, i. e., 1 c. c. of water at 4°C is one gram. In the illustration, figure 4, the effect is magnified. The real change on one c.c. is very small so that one c.c. of water at any temperature is close to one gram of water. A number of questions arise at once. Why does ice float? What would happen if water and ice contracted when cooled over all ranges of temperature? How could one deliver 1000 grams of sugar without the use of any balance if given volume measuring vessels? Would it be as easy to deliver one pound of sugar without a balance if given English volume measuring vessels?

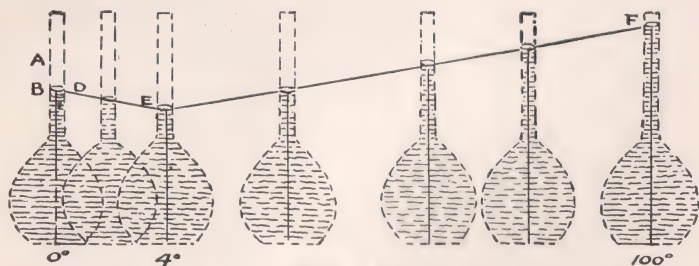


Fig. 4

Time: The well known units of time, especially the *second*, are used for any time measurements.

QUESTIONS

1. What kind of a subject is chemistry?
2. What is the scientific method?
3. What are some of the branches of science?
4. What was the situation in Chemistry at the time of the American Revolution?
5. What familiar idea was held regarding the make-up of our world? Of fire?
6. What are some of the activities in early times which we now know contribute to modern chemistry?
7. What guides a chemist in his study?
8. What does the chemist know about (a) Earth, (b) Air, (c) Fire and (d) Water?
9. What is a substance? An element?
10. How many elements are known?
11. How many elements are there likely to be known?
12. How many compounds are there?
13. What is a mixture? A component? Illustrate each.
14. What are the three characteristics of a mixture?
15. What is a compound? A constituent? A chemical reaction?
16. What are the two chief characteristics of a compound?
17. If coal is 90% carbon what weight of carbon dioxide can it produce when one pound of it burns in air?
18. What is a property? Name several physical properties.
19. Describe some substance in terms of its physical properties.
20. What is a physical constant? Name two for water.

THE SHORTHAND OF CHEMISTRY

Symbols

Observe the one and two letter symbols in the table given on Page 5. H after hydrogen, He after helium. Then Na after sodium, Fe after iron. So far as H and He, it would seem that we were choosing initials which refer to the name, but Na and Fe have no relations to the words sodium and iron. If, however, we refer to the latin words, natrium for sodium, and ferrum for iron, we can see the relationship. If

then you follow down the second column you will discover that the symbols are in most cases the first letter, and in case two or more begin with the same letter two letters are used, or letters from the name in some other language.

Symbols and Atoms

You might well ask why not call these letters initials, why call them symbols? The answer is that the abbreviations do not refer to the word at all but mean much more, e.g., H does not stand for the word hydrogen but for a little particle of matter, the smallest particle of the substance hydrogen which enters into chemical combination with similar particles of other elements to form compounds. These little particles are called atoms. Thus the second column should be read, one atom of hydrogen, one atom of helium, one atom of lithium, etc.

How Big Is an Atom?

When we answer this question, you might also ask, how do you know? We shall not attempt to answer the how. We shall ask you to believe the statements, accept them as facts and use them. There is no great advantage in knowing how the measurements were made unless you eventually become a chemist and become interested in this problem.

Let's take the hydrogen atom as an example.

If we had approximately 6.06×10^{23} atoms of hydrogen you would have one gram. A cubic foot of hydrogen gas weighs slightly more than two grams.

What does 10^{23} mean? $10^2 = 100$, $10^3 = 1000$, you may write $10^{23} = ?$ (1 followed by twenty-three zeros). What does that mean? That many pennies stacked as closely as possible would occupy a cubic space approximately 1000 miles on each edge. You see that it is a very large number, which means that the atom is a mighty small particle of matter. Strange as it may seem, the chemist deals with these small particles and interprets all chemical changes in terms of them. The numbers in the third column on Page 5 represent the relative sizes of the atoms compared with oxygen as 16. As indicated by the numbers to the right of the decimal point they are known very accurately.

A Chemical Formula

What does H_2O mean? You may answer water, but that is not a complete answer. It is the *formula* of water and tells us that hydrogen and oxygen are combined in the ratio of two atoms of hydrogen to one atom of oxygen. $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ is the formula of the sugar you use daily and means 12 atoms of carbon united with 22 atoms of hydrogen and 11 atoms of oxygen gives a substance which you call sugar. NaCl is the formula of ordinary table salt which is the result of the union of one atom of sodium and one atom of chlorine.

What Quantities Do We Deal With? Formula Weights.

Consider what has just been said about the size of atoms, then even the formula of a substance represents an extremely small amount of a substance, a particle smaller than we can deal with one at a time. It must be evident to you we must deal with large numbers of these small particles, either atoms or formulas, when we use any one of the substances. For that reason we usually consider the atom and formula in terms of grams e. g. we can say H stands for 1.008 grams of hydrogen, He for 4 grams of helium, Li for 7 grams of lithium, etc., which in each case means that we are dealing with 6.06×10^{23} atoms at a time. These are called gram atoms, i. e., the atomic weight expressed in grams. Likewise H_2O may stand for 18 grams of water, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ for 342 grams of sugar. These are called gram formula weights.

Quantities Involved In Reactions. Equations.

What does $\text{Fe} + \text{S} \rightarrow \text{FeS}$ mean to you?

According to your arithmetic it means $\text{Fe} + \text{S} = \text{FeS}$. To a chemist it means that 55.84 grams of iron will combine with 32.06 grams of sulphur to produce 87.9 grams of iron sulphide. The amount of material used equals the amount of material produced. If this were all it represented, then any two substances could be written as if when added to one another, a new substance would be produced. Some substances, however, do not combine, so it cannot be a matter of arithmetic.

Note that in the expression written above there is an arrow pointing, right, which means the thing will happen and the balanced expression tells in what ratio. Take for example $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$. This tells that hydrogen and oxygen are usually written H_2 and O_2 respectively and that water is H_2O . The arrow also tells us that hydrogen and oxygen will unite. It takes little effort to note that since water is two atoms of hydrogen and one atom of oxygen that the quantities in the expression above are not equal, but it is certainly simple to observe that if written $2\text{H}_2 + \text{O}_2 = 2\text{H}_2\text{O}$, the number of atoms on the right side is equal to the number of atoms on the left side, so that we may use an equals sign to express the relation. The first expression says that the hydrogen will combine with oxygen to form water and the second simply multiplies quantities so that we have a balanced expression.

$2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$ is the shorthand for saying that two atomic weights of iron unite with three formula weights of chlorine to produce two formula weights of iron chloride.

You will not at once completely grasp all there is in the shorthand of chemistry, but as you gain more familiarity with substances and their reactions with one another, its value as well as its significance will become more apparent. e. g. as stated above, when we speak of hydrogen we use the formula H_2 , for Oxygen O_2 and for chlorine Cl_2 . In the cases of hydrogen, oxygen, and chlorine, it has been shown that the atoms go in pairs to form small particles made up of two atoms each. In the case of Fe, Na, and C only one atom is used for the reason that it is not known whether they pair to form more or less stable particles. Whenever the formula of an element is represented by more than one atom, it is because there is some good reason to believe the element ordinarily exists in small units made up of the number of atoms indicated by the subscript.

We cannot go into a complete discussion of how the chemist has determined the formulas, but if you are interested in this point any college text book and some high school texts give it.

QUESTIONS

1. What does H mean? He? Au? Ag?
2. What does H_2O mean? $\text{C}_{12}\text{H}_{22}\text{O}_{11}$? NaCl ?
3. What does $\text{Fe} + \text{S} \rightarrow \text{FeS}$ mean?
4. Copper and sulphur combine directly to give copper sulphide as follows $\text{Cu} + \text{S} \rightarrow \text{CuS}$. How much sulphur is used to combine with 100 grams of copper? How much copper sulphide is formed?
5. What is an atom? How big is it?
6. What is the significance of the value 6.06×10^{23} ?
7. Show the relation, in terms of atoms, between water and its constituents.
8. What does H_2 mean? O_2 ? Cl_2 ?
9. What do the formulas of the following substances tell you?

Cane sugar— $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

Grape sugar— $\text{C}_6\text{H}_{12}\text{O}_6$

Baking soda— Na HCO_3

Saltpeter— KNO_3

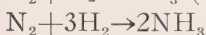
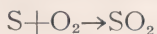
Table salt— NaCl

Acetic Acid— $\text{C}_2\text{H}_4\text{O}_2$

Sulphuric Acid— H_2SO_4

Carbonic Acid— H_2CO_3

10. What do the following expressions tell you?



PART I

To obtain a Merit Badge for Chemistry, you must:

Submit evidence of study and experimentation in Chemistry, and demonstrate your ability to apply the knowledge gained in discussing points outlined in Part I and carry out the experiments suggested in Part II.

1. *In building a fire one whittles or breaks sticks into small splints, starts the fire with a match, flint and steel, friction, or burning glass, and aids it with gentle fanning. Gentle fanning will aid, but violent fanning will extinguish a small flame. Very dry wood gives a hot fire; green or moderately wet wood will burn but give out little heat, while very wet wood will not burn. Discuss each point.*

Starting a fire by any of the means mentioned above depends upon friction and only in the case of the use of the match was any intermediate factor employed. The head of a match is a chemical preparation which is more sensitive to friction, and during the chemical reaction of this material started by the friction, heat is given out sufficient to ignite the match stick.

When any material burns in the air it combines with the oxygen of the air so that if the air remained stationary the oxygen supply would soon be exhausted. Gentle fanning pushes away the air from which some of the oxygen has been removed and puts a fresh supply of air in its place. There is another effect which "blows out" the fire. "Blowing out," is not generally understood. As you know the burning material did not begin to burn until its temperature was raised and if anything cools it off too much it will just quit burning. If then you can blow enough cold air over the burning substance you can lower its temperature so that it will be too cool to burn.

Another very important point in starting a fire is how much heat does the burning material give out, and that depends largely upon the dryness of the material. Green wood contains considerable moisture which can be gotten rid of

by the slow process of drying or seasoning or by the application of heat to hasten the drying or seasoning. You have heard of "kiln dried" lumber, which means that the lumber was dried in a large hot room or chamber called a kiln. Whether it dries slowly or is forced to dry rapidly it takes considerable heat energy to drive out the water.

It is not difficult then to realize that if some of the heat resulting from burning is used to drive off water that the remaining material will not get very hot and will not burn as rapidly. If you are to get heat to warm the space surrounding the fire it must not be all used up in getting rid of the water in the green or wet wood.

Spontaneous combustion results from the accumulation of heat resulting from a slow chemical reaction taking place where the heat does not escape as rapidly as it is generated. When this reaction is taking place in contact with combustible matter (old rags for example) this material finally reaches the kindling temperature and a real fire starts.

If you are careful to protect the point of contact of a friction between two sticks from loss of heat your fire will start much more quickly.

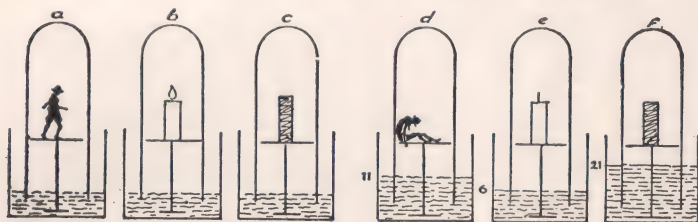
It is evident then a little thought about the nature of fire will save much time lost or even failure in building a fire.

Another problem associated with fire, second only to how to start a fire, is how to extinguish a fire. The second problem also requires an understanding of the nature of fire. If the two main requirements for fire are that a fresh supply of oxygen is continually necessary, and that heat must not be too rapidly dissipated, then the removal of either or both should extinguish the fire. Putting water on a fire does both at once. It uses up the heat and its steam pushes the air and oxygen away from the burning material. Sometimes you cover a fire with sand and thus exclude the air, sometimes carbon dioxide gas is used to push the air away or dilute it so it does not supply a sufficient amount of oxygen, and sometimes a blanket (of course the blanket may get hot and begin to burn on its outer side where it is in contact with the air). The throwing of salt in a burning chimney is sometimes effective. The bricks which are covered with inflammable soot, or have absorbed some volatile inflammable material

get very hot and salt when thrown onto them while hot gives a thin coat of melted salt and thus excludes the air. Throw some salt onto some burning coal, allow to cool and examine the surface of the coal.

2. Suppose one has three very large bell jars or bottles inverted over a trough of lime water, thus inclosing air and sealing so that air can neither escape nor enter. Suppose one puts a boy into one, a lighted candle the size of the boy into the second, and a piece of phosphorus the size of the boy into the third. Soon the water will begin to rise in each. When the water has replaced 11% of the air in the first, the boy will collapse; when 6% of the air in the second is replaced, the candle will cease to burn; and when 21% of the air is replaced in the third, no more change will take place. Fully interpret and explain.

See Figure 5, a, b, c, d, e and f. At the end of the experiment, water must be added to the outer vessels so that the levels will be the same outside as on the inside. Note that the water levels in d, e and f, are above where they were in a, b and c, 11, 6 and 21, units in comparison to one another on the basis that the tubes were each 100 units long.



At the beginning

Fig. 5

At the End

Note (The lime water absorbs the gases given off during the respiration of the boy and the burning of the candle and phosphorus).

The air is about 21% oxygen, so it is evident that the phosphorus can use the last trace of it, but 10 of the 21 parts are of no use to the respiration of the boy while 15 of the 21 parts can not be used to aid in the burning of a candle. These are interesting facts, but unless shown to be true

by experiment one would never have suspected the results. It is extremely important to know the amounts of oxygen necessary to support combustion and respiration.

The amount of oxygen in the air can be determined by a very simple experiment with a bottle, iron filings and a dish

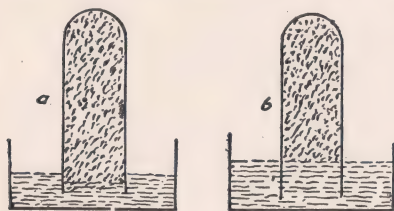


Fig. 6

of water. First moisten the inside of the bottle or large test tube and then scatter iron filings into the bottle. Invert the empty bottle or tube, bottom side up into a pan of water (a). Figure 6. Allow to stand a day or so noting occasionally the level of the water inside the bottle. Finally when

no more change takes place, add water to the outer dish until the water is level with that inside the tube (b) and then determine what portion of the inverted bottle is occupied by the water. Explain.

3. Give (a) *A list of the sources of water.*
- (b) *A list of the uses of water.*
- (c) *A list of the impurities found in water.*
- (d) *A classification, with respect to injurious nature, of the impurities.*
- (e) *The special problems confronted in obtaining, treating and storing water for drinking purposes.*

We may assume that the amount of water on the earth's crust varies very little, but the water in rivers, lakes, seas, and oceans, is continually evaporating and then returning, sometimes quite a distance from its origin, in the form of rain and snow. This is then returned through tributaries and subterranean seepage to the rivers, lakes, seas, and oceans. Sometimes rain water or that from melting snow is collected

for use but in general we go to rivers, lakes, seas, oceans, or by means of a well or spring to some subterranean deposit.

If we consider the sources of water enumerated above it is easy to anticipate the impurities which we will find. Rain water will be the purest, for as it leaves the ocean or other source in the form of vapor all impurities except gases or volatile substances are left behind. The gas or volatile substance, of course will be augmented by soluble gases in the air, but the sum total of these gases or volatile impurities is not serious, and such water is the purest found in nature.

The water of oceans, rivers, seas, lakes and subterranean origin is contaminated with two classes of impurities, dissolved and suspended. A clear body of water has little suspended impurity, but a muddy body of water, not only has dissolved impurities but suspended. The amount of either class of impurity depends largely upon the locality. The sea contains little suspended material but does contain much dissolved matter, especially ordinary table salt. In reality as the river brings water from inland sources it carries the soluble part of the earth. This has happened in some places to such an extent that certain inland lakes have become so salty that they are deposits of brine or even dry salts. Explain the salty condition of the Great Salt Lake in Utah.

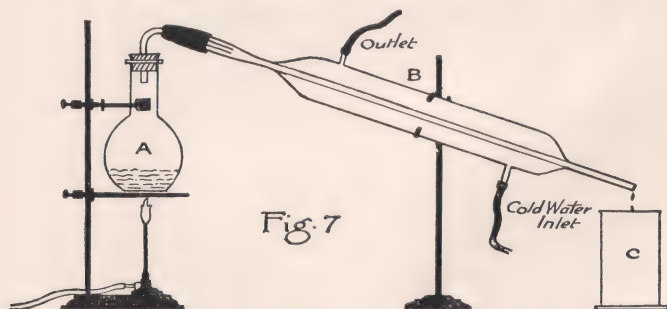
Another impurity is bacteria. There are two kinds of bacteria, pathogenic and non-pathogenic. The latter may be quite harmless but the former causes disease. Thus for drinking purposes we must know about the pathogenic bacteria, as well as the nature and extent of dissolved or suspended impurities. Pathogenic bacteria will not hurt the steam boiler, but dissolved impurities cause boiler scales or even attacks the boiler. On the other hand certain dissolved "impurities" are desirable for drinking purposes. Suspended impurities on the other hand are objectionable for any purpose.

Let us first consider the problem of getting rid of suspended matter. Of course we might choose a source where the suspended matter is not present, e. g., rain water or springs, but such sources are not always convenient. Suspended matter occurs in two conditions, that which can be readily removed by filtering and that which passes through the best filters. The first kind is ordinarily removed by passing water through a bed or bar of sand, while the second

requires treatment before the very fine particles collect into large enough groups to cause settling or to be caught by an ordinary sand filter. This is often accomplished by adding lime and alum, especially in case of fine clay suspension, after which the suspended matter readily settles. When properly applied the lime and alum react with one another and the clay so that they are a part of the material settling out thus leaving little added dissolved impurity.

Filtering out suspended matter often cuts down the amount of pathogenic bacteria, but does not make water safe to drink.

A second problem is the dissolved impurity. Water must always be selected either for drinking or industrial purposes with a full knowledge of the nature of such dissolved matter. Suppose we had only sea water we could neither drink it nor use it in a steam boiler. The only possible method to prepare sea water is to distill it leaving behind the more volatile salts which are dissolved in it. Distillation is a process by which you cause a volatile liquid to change to a vapor and then by cooling condense it back to a liquid thus separating the more volatile from a less volatile substance. Figure 7 illustrates a common laboratory method for such a purpose.



The flask A contains the sea water and is connected through a glass tube to a "Liebig" condenser B. A dish C is placed at the open end to receive the water which results from condensing the vapor which forms as flask A is heated. The Liebig condenser has an inner tube surrounded by a larger tube with two outlets so that cold water can be kept circulating around the inner tube. The water vapor (steam) is thus condensed as it passes through the inner tube.

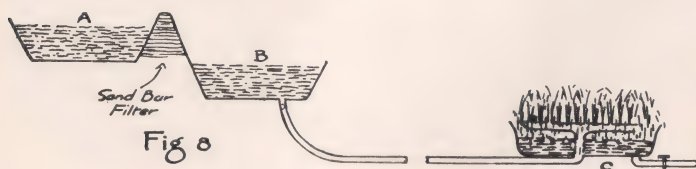
Fortunately it is usually possible to find water suitable for drinking and industrial purposes. Strange as it may seem, dissolved impurities are more serious objections for industrial purposes than for drinking purposes. We can drink water which if put into an engine boiler would form, after a time, a scale so thick on the inside of the boiler that it would be almost impossible to heat the water. In fact many pipes carrying drinking water get filled up by deposits on the inside of the pipe. We can also drink water too "hard" (the hardness is caused by certain dissolved impurities) to use for laundry purposes.

The third problem, pathogenic impurities, concerns only drinking water. There are treatments such as "chlorination" which will destroy such bacteria, but we should always select a source which carries no such impurity. Care in selection and storage will insure the safest supply. Where large communities are served from some large storage reservoir, a constant check is kept on the water to discover and treat with an unexpected contamination.

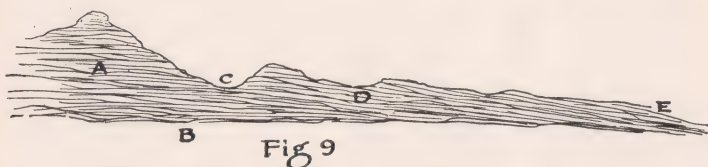
Another impurity often found in drinking water is odors, not necessarily injurious but objectionable. Such impurities are removed by aeration. Water may be brought by gravity through a large pipe for several miles and when released will spurt many feet into the air. If such openings are small then the fine streams become a mist which becomes intimately mixed with the air. The gases causing the odor escape and the water is thus made palatable.

Let us sketch two problems:

1. Water is collected in a reservoir A up in the mountains and allowed to filter through a sand bar into a second reservoir B from which it is led for many miles underground and when released through fine openings pointing upward it spurts into the air and finally falls aeriated into a reservoir C from which it is distributed. See Figure 8.



2. Water is to be taken from a spring. A spring results from water filtering down through the earth until it strikes an impervious layer and as it accumulates it finds an outlet at some low point. See Figure 9. Water falling above A, settles through the earth until it strikes B (clay e. g., which is more or less impervious to water). As the water accumulates



it will rise until it comes out at C. If the area of A is large it may accumulate so rapidly that it will spurt upward like a little fountain at C. It may form a little lake or enter D and continue on along B until it reaches E where it will appear as a second spring.

With such a picture in mind it will be quite clear that if you wished to use the water at C you would not wish to have a source of contamination on the higher ground A. If you were to build a private sewage disposal plant and use the water at C you would exercise especial care not to have the seepage from it going into the earth directly in line with the spring. If you were to drive a well it would be safer to have your well strike the impervious layer higher up than any seepage from refuse or sewage. A little thought about subterranean sources of water, wells and spring, will aid greatly in selecting sites for water supply and sewage disposal.

4. *A good Scout keeps his knife, axe and iron cooking utensils clean and dry, and as far as possible equips himself with aluminum canteens, etc. Explain.*

One of the most common characteristics of metals is their tendency to "react" with oxygen of the air to form oxides or with sulphur to form sulphides. This coating of oxide or sulphide is known as tarnish. Silver, gold, and platinum, and to a certain extent nickel and chromium are exceptions. Other metals notably copper, aluminum, lead, zinc, and tin react. Sometimes the result is a thin adherent layer or protective coat under which the metal remains unchanged. As

you know copper, tin, lead, and zinc, are used for roofs, rain pipes, etc. The effect on copper is most conspicuous for a bright copper roof soon becomes greenish and finally very dark green. While the same thing happens to tin, lead, and zinc it is not so noticeable. Iron on the other hand just keeps "reacting" until there is no iron.

At first thought, it would seem that we might use any of these metals as cooking utensils or food containers. This is impossible, for foods often react with metals. Iron and aluminum are more often used as cooking utensils, but other metals such as tin and copper are sometimes used. Metals react so readily with some foods that it is necessary to cover the inside of the can with a protective coating before canning such foods. Copper and lead may form compounds which are poisonous and food should not be stored in these. While brass, an alloy containing copper is used for conveyors of drinking and cooking water, lead should not be so used.

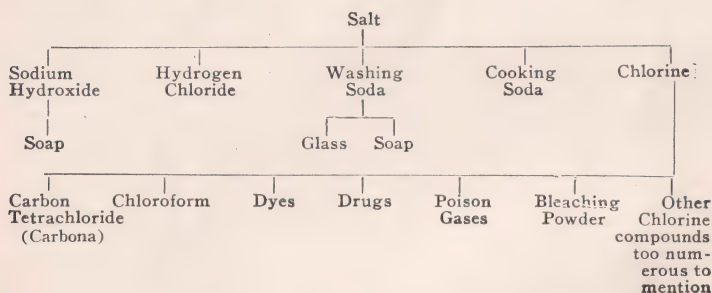
It must also be kept in mind that metal implements which react readily with oxygen and sulphur, react more rapidly when wet and "dirty".

5. Every boy uses salt in seasoning his food. Assume you have a salt mine and the whole world is dependent upon your mine and upon your knowledge of what might be done with it. Give a full discussion of what you might produce, provided all other chemicals and our present-day chemical machinery were available.

There are a large number of substances which may be classified under three headings, acids, bases, and salts, the latter of which comprise the larger number. "Salt" as we use the word to refer to that used on the table is indeed a very restricted use of the term but the use of this term in this sense is universal. This salt—sodium chloride—is found dissolved in oceans, in large deposits as a white solid and in "salt-wells" as a heavy brine—a saturated solution and suspension. Whether it is found in the solid state or in the brine it can be brought to the surface by pumps. Of course water must be added to a solid deposit before it can be pumped. After getting the brine into a large reservoir, the saturated solution is filtered into a

second reservoir where the water evaporates and clear white crystals of "salt" separate. Since all salt contains other soluble impurities it is never allowed to evaporate to dryness for then the salt would contain the impurities such as bromides, iodides, and sulphates. When the solution approaches saturation with respect to the impurities the mother liquor is drained from the salt which is quickly washed with cold water to remove the traces of the mother liquor which contains the impurities. The salt is then ready to market as "salt." Sometimes it must be recrystallized i. e., brought again into solution and allowed to evaporate nearly to dryness again. How many times it must be recrystallized depends upon the nature and extent of the impurities in the original deposit.

As a chemical, salt is very valuable. Its use is fully described in the text book which you use. A brief summary follows giving substances prepared with salt as one of the starting materials.



PART II

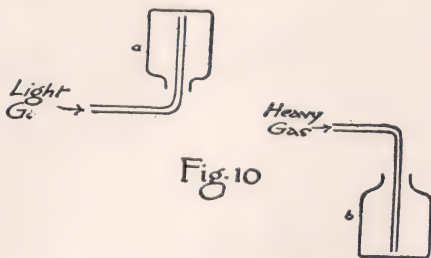
No attempt will be made to give a complete discussion of the tasks indicated in 6, 7, 8, 9 and 10. For such a discussion would only duplicate the subjects more fully discussed in the text book which a Scout must use in his preparation for the Merit Badge test.

Note: No Scout should attempt an experiment not fully described, unless directed by some one competent to outline the procedure. Many amateur chemists have burned their homes, lost eyes, hands and even their lives by not heeding this warning.

1. *Prepare and collect two of the following gases: Oxygen, hydrogen, chlorine and ammonia.*

Whenever a Scout attempts to handle and collect a gas he should know first of all, all the hazards involved, such as poisonous character, or tendency to explode when mixed with the air. Of the four above, *chlorine is very poisonous, ammonia moderately so and hydrogen is explosive.* Oxygen then is the only one which does not need especial caution in handling.

The usual method of collecting a gas is by displacement of water or air, and which of the two methods to be used depends upon whether or not the gas is soluble. Oxygen, hydrogen, and chlorine may be collected over water but each is somewhat soluble, oxygen and hydrogen slightly, but chlorine moderately so. Ammonia is extremely soluble, so it is best collected by displacement of air? If the gas is light the air should be displaced downward, Figure 10, A; if heavier, the air should be displaced upward, Figure 10, B.



Figures 11, 12 13 and 14 on the opposite page represent the arrangement of apparatus for the liberation and collection of oxygen, hydrogen, chlorine, and ammonia respectively.

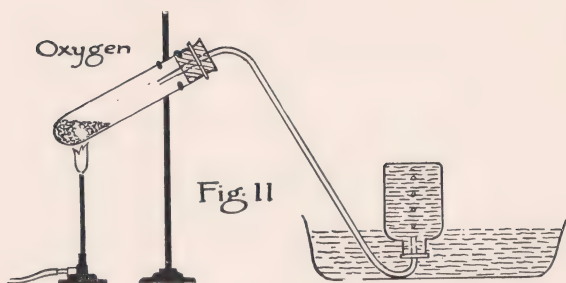


Fig 11

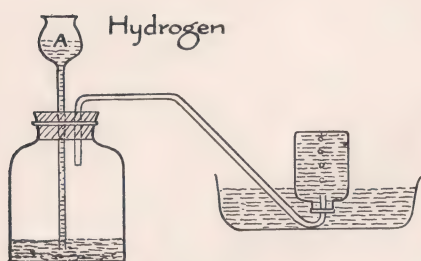


Fig. 12

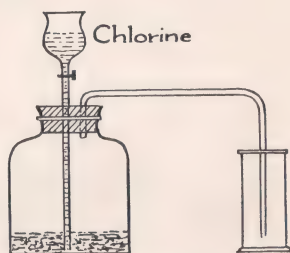


Fig 13

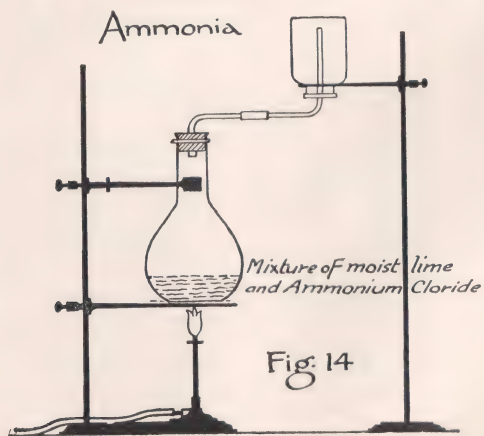


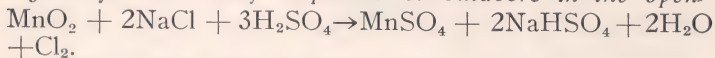
Fig 14

In Figure 11, potassium chlorate is being heated. Upon heating, potassium chlorate decomposes, expressed in the shorthand of Chemistry as follows, $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$, to give potassium chloride and oxygen.

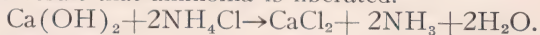
In Figure 12, dilute sulphuric acid is added through the thistle tube at A into the bottle which contains zinc metal. The bottle is fitted with a two-holed rubber stopper carrying the thistle tube and the delivery tube leading to a trough of water where the hydrogen gas is collected by downward displacement of water. Caution! Hydrogen mixed with air is explosive. Keep all flames away. $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$.

In Figure 13 sulphuric acid is added through the funnel drop by drop (see stopcock) into a mixture of sodium chloride and manganese dioxide. As the chlorine is liberated it is led into a cylinder or bottle where it displaces the air. Note that the delivery tube reaches to the bottom of the collecting vessel as it is a heavier than air gas. A paper cover will aid in keeping the chlorine gas from diffusing out.

Caution! Chlorine gas is poison and should be collected in a good fume or draft cupboard or outdoors in the open.



In Figure 14 ammonia is being collected by downward displacement of air as ammonia is a lighter than air gas. A mixture of ammonium chloride and moist lime is being gently heated with the result that ammonia is liberated.



2. Find out which, if any, of five substances given you are carbonates, sulphides, or chlorides.

You will go to your Counselor for a list of the five substances to be tested under this requirement.

Note to Merit Badge Examiner or Counselor: Naturally no substance will be given which under any circumstance will cause a complication when tested as follows:

a. *Test for a carbonate.* Place the substance to be tested in a test-tube fitted with a one-hole stopper and bent glass-tube which ends in a test tube containing lime water. See Figure 15. Add a little dilute hydro-chloric acid, quickly insert the stopper and if the substance is a carbonate, carbon dioxide will be liberated and will bubble through the lime water giving a white precipitate of calcium carbonate.

b. *Test for a sulphide.* If the sulphide is soluble put it into a test tube and add a little dilute hydrochloric acid, warm and add a few drops of copper sulphate solution. A black precipitate will indicate a sulphide. Any sulphide can be recognized by passing oxygen over the heated sulphide in which case sulphur dioxide gas will be produced which when led through a dilute solution of potassium permanganate in water (purple solution) will destroy the color. The test can be further verified, for, as the sulphur dioxide destroys the color a sulphate is formed. If then barium chloride is added to the decolorized solution a white precipitate will form if the sulphate is present.

c. *Test for a soluble chloride.* A soluble chloride may be recognized by adding a little diluted nitric acid and a few drops of silver nitrate solution. A white precipitate of silver chloride forms if the chloride is present.

3. *Find out which, if any, of several liquids or solutions given you are acids or bases.*

There are certain substances of which litmus is the most common, that give a characteristic color when in contact with an acid or base. Litmus is very sensitive to either. Solutions of acids turn litmus pink and those of bases turn litmus blue. Test fruit juices and vinegar. Test a soap solution.

4. *Extract metallic copper from its black oxide.*

Intimately mix powdered oxide of copper with powdered

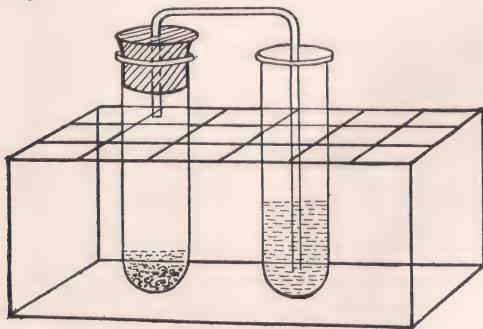


Fig. 15

charcoal and heat in a test tube, as in Figure 11. Lead any escaping gas through lime water. Note the effect in the lime water and examine the residue from the heated mixture. If the mixture is heated sufficiently, small particles of copper will be formed.

5. *Give two experimental demonstrations that some substances catalyze certain reactions.*

Take two portions of about two grams each, of potassium chlorate and put them into two separate test tubes. To one add a little manganese dioxide. Gently heat both and test each for escaping oxygen (with glowing splint) and thus determine which yields oxygen more rapidly.

Take two small pieces of zinc, wind one with fine copper wire and put into two separate test tubes. Add dilute hydrochlorine acid to each. Which liberates hydrogen gas more rapidly?

Caution when using manganese dioxide above. Be sure it is manganese dioxide. Manganese dioxide is black and looks like powdered charcoal. *Do not take a chance and go merely by color.* Know that what you are using is manganese dioxide and nothing else.

Don't finish your preparation for meeting the Chemistry Requirements without taking the time to read the following interesting story of the field of chemistry as a life work which has been prepared for you by the Boy Scouts of America. There may be in it the one hint which will decide for you that big question of a life work and how you as an individual can meet it.

CHEMISTRY AS YOUR LIFE WORK

J. R. Boardman

At six years of age, Thomas Graham, renowned Scotch chemist, entered preparatory school, at nine high school, at fourteen the university. He was like other boys of his day, perhaps a bit more diligent, studious, conscientious. His father insisted on the ministry, but the son regarded himself as naturally unfit for it. Philosophy and chemistry were already his major interests and he won the confidence and admiration of his instructors by shrewd observations and questions. The secrets of nature challenged him and he later solved many of them in the borderland between physics and chemistry. He had a genius for investigation, and even in his early 'teens laid the foundations for his later outstanding achievements.

And so, perhaps your own study and work in earning this Merit Badge may awaken a natural aptitude for chemistry, stimulate a desire for continued study of it, and result in a decision to consider it seriously as a field for your own life work.

Chemistry as a Career

There are few fields which offer a more attractive life work career than chemistry. It is bristling with intensely interesting problems, the solution of each one revealing still others beyond. If you love to experiment, explore, discover, if you crave to do something no one else has ever done, to find something heretofore unknown, to uncover something hidden for ages, to take things apart to see what they are made of and then put those parts together in new combinations, then this particular vocation—chemistry—may appeal to you as a life work of fascinating and humanity-serving activities.

Materials and Tools

Solids, gases, liquids,—these are the substances with which the chemist works, his fertile brain and deft fingers constantly suggesting and producing new mixtures and compounds which will add still further to the health, happiness, and wealth of the world of men.

Did you ever see a successful chemist's laboratory? No other work shop in all the world is like it. It is equipped with unique devices of peculiar construction and particular purpose. Retorts, ovens, dryers, desiccators, beakers, bottles, jars, test tubes, baths, filters, vaporizers, condensers—these are some of the many instruments the chemist uses in finding what things are made of and in making his new products—products which are his own discoveries, his own contributions to the well-being of his fellow men. Do you see yourself as the master workman in such a workshop?

Help in Deciding

The earlier you decide one question the better. You know what the business of the chemist is, the materials and tools he works with, the goals he sets before him. Do these things vitally appeal to you? If so, this statement will help you to decide how permanent that appeal is, how practical it is in terms of hard study and hard work—in other words, it will help you to “find yourself” and to decide whether chemistry is to be your life work.

As a Scout on the “Be Prepared” basis, you would probably like to know whether or not you have the “makings” of an A1 chemist in you. Unfortunately, there do not seem to be any tests reliable enough to help you answer that question as quickly as you would like.

But what you can do is to find out the kind of man today's successful chemist ought to be; what his characteristics, habits, capacities and abilities ought to be. Notice we say “ought to be” rather than “are.” Therefore, we are giving you here a sort of “composite photograph” of the essential characteristics of the “ideal” chemist. Here they are:

Insatiable curiosity—Curiosity that is working all the time, never satisfied. A question mark—that is the sign of the real chemist. “I wonder”—those are the key words to his success.

Constructive imagination—The ability to see things that aren't there yet but which will be before he gets through. Creative thinking. The ability to originate and perform experiments in his brain before he tests them in the laboratory.

A logical mind—The power to think clearly, correctly, to connect causes with their actual results, to think results back to their actual causes, so far as possible.

Acceptance of facts—He must not yield to half-truths, prejudices, fads, fancies, substitutes. He demands facts, is satisfied with nothing else even if they knock out his theories. These are the only final results worth anything. They must be the basis of all his work.

Determination—He never gives up until the essential facts are his. There are seemingly unsurmountable obstacles in his work. He must go over, under, around or through them, fighting every step of the way with patient but dogged persistence, until the true result is his, whether he likes it or not. At times he practically lives in his laboratory, often sleeping there to be near his students and assistants. That is one of the costs real men pay for success—hard work and lots of it.

Accurate observation—This successful chemist must get things as they are, exactly. Sight, taste, smell—these senses must be keen. His success will be very largely measured by their perfectness. Accurate recording must follow accurate observation. The memory is tricky. Data must be recorded as observed, and recorded fully and accurately.

Neatness and cleanliness—The elements the chemist works with are absolutely pure. So must be his laboratory apparatus—clean, sterile. He hates dirt, untidiness, sloppiness. It ruins the reliability of experimental work, and the results are useless because the truth is not in them.

Precision—The chemist works with extremely active materials. Ignorance and carelessness are serious defects. No real chemist is ignorant. It is unthinkable, unpardonable. He must know what he is doing as far as it is humanly possible, otherwise he should not do it. Eternal watchfulness must be maintained. The results of carelessness may be fatal.

Team work—The narrow minded, selfish, grasping egotist is seldom the great chemist. The great chemist uses truths

found by others, adds his own proved facts and passes on the net results to the discoverers in tomorrow's laboratories. A number of America's ablest research chemists merged into a cooperating unit at the American University Experiment Station in Washington during the World War, secured amazing results in record time by working together every hour, wholeheartedly. The experts in other sciences added their findings to the sum total knowledge of this victorious group of specialists. Its results would have been impossible otherwise.

Manual dexterity—The chemist's hands are his only live personal instruments. Their skillfulness, by nature and training, contribute very definitely to his success. This is particularly important in the chemist who must do his own laboratory work.

Now Measure Yourself

Read these qualifications through again, and with this picture in mind, measure yourself against it as to the extent to which you personally possess these characteristics. It is not an easy thing to do, but you have a standard by which to judge yourself in the things you do from day to day, in school, in Scouting and at home. Above everything else you must be honest with yourself in this test. If the essential qualities are missing or are poorly developed, the question for you to answer is whether or not you are willing to undertake to build yourself up in the things in which you find yourself deficient.

STANDARDS AND TRAINING

The Scout who is attracted to the field of professional chemistry as a life work must reconcile himself to long years of preparatory educational training. The standards of the leading organizations of chemists are very high. The importance of exactness and thoroughness in the technical work of chemistry, the fact that its work is concerned very largely with the protection of human life, where mistakes are often fraught with serious or fatal consequences—these conditions are responsible for this insistence on adequate preparation.

Educational Basis

The Committee on Professional Education of the American Institute of Chemists, in a report made at one of its conventions, listed the following essentials: English, including rhetoric, English literature, writing and public speaking; Modern languages, especially German and French; Economics, including cost accounting and business administration; Mathematics; Physics, including theoretical and experimental work in mechanics, heat, light and electricity; Chemistry, inorganic, physical and organic; Humanities, including history, philosophy and psychology; Electives in biological and social sciences, geology, mineralogy and free hand drawing.

This program carries on through high school and college, or technical school. Two additional years of post graduate work, largely in chemistry, should lead to the degree of Master of Science in Chemistry and to recognition as a professional chemist. Advancement in the profession depends on the enrichment of this essential background, and the degree of Doctor of Philosophy is regarded by the entire profession as very desirable additional equipment.

Select Helpful School Studies

As early as possible in his school work, therefore, the Scout should select such studies as fit into this required course of training, as will acquaint him with his own aptitudes and capacities and initiate him into the subject of chemistry itself, a knowledge of its vocabulary, and an appreciation of the difficulties of the subject as presented in college or technical school.

Vocational schools are increasingly conducting courses for the training of laboratory workers. The instruction given is largely for development of the required skills, with training in theory only as required to an understanding of the particular work to be done. Many elementary school graduates are used in these junior occupations, the average student requiring two years in the vocational school in addition to the school work he has already done. These vocational school graduates have little difficulty in securing excellent positions, and this would seem to be one of the best avenues for securing employment in these lines, as the demand for such

technicians is well in excess of the number of vocational school graduates available. A very satisfactory starting salary is paid for such juniors, according to their ability and experience. Opportunity for advancement is good, with consequent increase in earning power, but it is necessary to secure additional college or technical school training to qualify as a professional chemist. Notable work is being done in training these technicians in the vocational schools in Wilmington, Del., and Newark, N. J., and the system is being rapidly extended to other vocational schools where chemical and other allied industries are largely represented.

The vocational material offered in this treatment may also be applied generally to professional work in several vocations which are very closely related to the science of chemistry, viz., medicine, pharmacy, surgery, dentistry, public health, sanitary engineering.

EMPLOYMENT

Under normal business conditions, the Scout who is able to cover the full training period will have little or no difficulty in securing a satisfactory position on graduation, with open avenues for promotion to high levels in professional chemistry.

Positions of this character are open in many industries which manufacture chemical products or use large quantities of chemical products in their own processes. Here are a few typical industries of this class: textiles; pigments and paints; oils, fats and waxes; soap; perfumes; petroleum; coal tar products; resins and gums; varnish; sugar; dye stuffs; paper and cellulose; leather; glue, gelatin and casein; explosives; fertilizers.

In the industries allied to chemistry the United States Census lists several hundred different kinds of positions in which "operatives" are employed. This group does not include laborers, nor does it include the administrative or professional workers. The "operatives" must have particular "skills" for their work.

Employment Agencies Available

Most of these industries have their own employment agencies. The higher grade of general employment agencies also specialize in such placement. The Chemists' Club, 52 East 41st Street, New York City, has an employment bureau, which operates in the field of professional chemistry. Assistance among members of The American Chemical Society is given as far as possible by more than fifty local sections of that Society, scattered over the entire country. Practically all colleges, universities, technical schools and trade schools maintain their own placement bureaus, and undertake to locate as many graduates as possible in positions suitable to their training and experience.

Openings for Teaching

There is a call for a definite number of people to teach chemistry as a separate subject or as a part of the general science courses in high schools or evening schools. A normal course is usually required for such positions. Given outstanding ability as a chemist, advancement to an assistant professorship or professorship in college, technical school or university is always open to those who possess real ability as teachers.

A Long Time Occupation

A real chemist in good health who has kept up-to-date in theory and practice should maintain his earning power longer than the workman in many other lines. Experience should bring increased income with the added years. There are no legal or trade restrictions to limit him as to hours or wages, and if he conducts an independent research laboratory of his own he may, within reasonable limits, select his own clients and control his own charges. As an industrial chemist he must of course adjust himself to the conditions and requirements of the company which employs him. Research work takes its own time and produces factual results. Because of this, it must be kept in mind that such work often means slow progress and irritating and unwelcome findings, which must either be explained or endured, and in either event may affect income. In Germany, where research chemistry attained a high state of development, salaries were

supplemented by the payment of a bonus for the piece of work which materially saved expense or increased revenue.

There are few vocations where the range of knowledge and skill cuts a greater figure as regards compensation than in chemistry, especially professional chemistry.

Among operatives in plants where only a superficial knowledge of chemistry is required, and where the technical efficiency is developed largely by repetition within a limited field, compensation is about the same as in manufacturing plants in general, especially as it applies to junior labor.

As higher grades of knowledge and technical skill are required, we begin to get into employment grades where the cash value of training is recognized and wages are governed accordingly. Salaries depend largely upon efficiency, as do promotions. Conditions and personalities vary greatly, and it is just these factors which determine the character of the position occupied and the compensations received. Knowledge, skill, personality, and hard work are the things which control earnings.

Getting Valuable Information

Here are some suggestions which may aid you in getting important information. First of all, you will of course discuss your plans with your parents. The local school officials will be able to help you a great deal. Through them you can make valuable connections with the Department of Education at your own State Capitol, the United States Commissioner of Education, and with colleges and technical schools in your vicinity. Local doctors, druggists and dentists will know much about chemistry, and can tell you how to secure connections with chemical societies that will gladly give you wise counsel. There are in many communities industrial concerns using chemical products and employing chemists or chemical engineers. These will be able to give valuable information about available positions.

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YOU AND YOUR MERIT BADGE COUNSELOR

When you are interested in something, you have twice as much fun if you talk it over with a man who really knows his stuff—like your merit badge counselor.

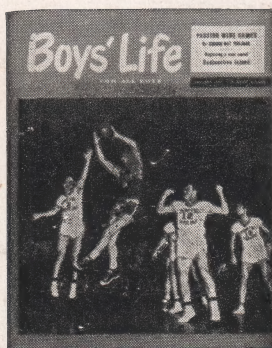
A counselor is usually a busy man. That's why you make an appointment with him ahead of time. Be there on time! Don't waste his time. If you can't be there, call him well in advance.

Your counselor usually has special equipment, collections, or materials to show you. If the subject is photography, he may have a perfectly equipped darkroom in his cellar or attic. If it's woodwork, the chances are he has a workshop filled with every kind of tool and gadget. Or perhaps it's astronomy, and the counselor will want to show you some things on night field trips. Each counselor's storehouse of interesting things is different.

Your counselor doesn't expect perfect book knowledge from you, but he wants to know that you have made a careful study of the subject. He also wants to know that you can do things with the knowledge that you have gained.

No Scout or Explorer wants a counselor to let him slide through the requirements just because he tried hard. When your counselor gives his approval, you want it to be because you have done a job you can be proud of, with no favors asked.

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for your
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